# OBSERVATIONS & RECOMMENDATIONS

After reviewing data collected from **PARTRIDGE LAKE, LITTLETON,** the program coordinators have made the following observations and recommendations:

Thank you for your continued hard work sampling the lake this season! Your monitoring group sampled **three** times this season and has done so for many years! As you know, multiple sampling events each season enable DES to more accurately detect water quality changes. Keep up the good work!

In August 2005, staff from DES gave a presentation on the findings of the Partridge Lake Diagnostic and Feasibility Study. Following that meeting, copies of the draft report were shared with the Partridge Lake Property Owners Association and lake residents for their review and comment. Plans are being made to make another presentation before key members of the town planning and conservation commissions, and other interested parties.

In the fall of 2005, the Partridge Lake Property Owners Association (PLPOA) submitted a Section 319 Watershed Assistance Grant proposal to develop a watershed based plan, develop and distribute a watershed guide, and design and implement stormwater best management practice projects within the watershed. The total project cost will be approximately $50,000. The PLPOA will receive $30,000 in Section 319 grant money from DES. The remaining $20,000 will be soft-match sources from the PLPOA and the Town of Littleton. The PLPOA will also be assisted by a pre-qualified DES consultant and has full support from the Littleton Town Administrator.

## FIGURE INTERPRETATION

- **Figure 1 and Table 1:** Figure 1 (Appendix A) shows the historical and current year chlorophyll-a concentration in the water column. Table 1 (Appendix B) lists the maximum, minimum, and mean concentration for each sampling season that the lake has been monitored through VLAP.

  Chlorophyll-a, a pigment found in plants, is an indicator of the algal abundance. Because algae are usually microscopic plants that contain chlorophyll-a, and are naturally found in lake ecosystems, the chlorophyll-a concentration measured in the water gives an estimation of the algal concentration or lake productivity. **The median summer chlorophyll-a concentration for New Hampshire's lakes and ponds is 4.58 mg/m$^3$.**

  The current year data (the top graph) show that the chlorophyll-a concentration ***increased slightly*** from **June** to **July**, and then ***decreased slightly*** from **July** to **August**.

  The historical data (the bottom graph) show that the 2005 chlorophyll-a mean is ***approximately equal to*** the state median and the similar lake median (for more information on the similar lake median, refer to Appendix F).

  Overall, the statistical analysis of the historical data (the bottom graph) shows that the mean annual chlorophyll-a concentration has ***not significantly changed*** since monitoring began. Specifically, the chlorophyll-a concentration has ***fluctuated between 4.15 and 19.5 mg/m$^3$,*** and has ***not continually increased or decreased*** since **1989.** (Note: Please refer to Appendix E for the detailed statistical analysis explanation and data print out.) It is important to point out that the **2005** annual mean (**4.15 ug/L**) is the ***lowest*** annual mean that has been measured since monitoring began.

  While algae are naturally present in all lakes, an excessive or increasing amount of any type is not welcomed. In freshwater lakes, phosphorus is the nutrient that algae depend upon for growth. Algal concentrations may increase as nonpoint sources of phosphorus from the watershed increase, or as in-lake phosphorus sources increase (such as sediment phosphorus releases, known as internal loading). Therefore, it is extremely important for volunteer monitors to continually educate all watershed residents about activities within the watershed that affect phosphorus loading and lake quality.

- **Figure 2 and Table 3:** Figure 2 (Appendix A) shows the historical and current year data for lake transparency. Table 3 (Appendix B) lists the maximum, minimum and mean transparency data for each sampling season that the lake has been monitored through VLAP.

  Volunteer monitors use the Secchi-disk, a 20 cm disk with alternating black and white quadrants, to measure water clarity (how far a person can see into the water). Transparency, a measure of water clarity, can be affected by the amount of algae and sediment from erosion, as well as the natural colors of the water. **The median summer transparency for New Hampshire's lakes and ponds is 3.2 meters.**

  The current year data (the top graph) show that the in-lake transparency ***decreased*** from **June** to **July**, and then ***increased*** from **July** to **August**.

  It is important to note that as the chlorophyll concentration ***increased*** from **June** to **July** the transparency ***decreased***, and as the chlorophyll concentration ***decreased*** from **July** to **August**, the transparency ***increased***. We typically expect this ***inverse*** relationship in lakes. As the amount of algal cells in the water ***increases,*** the depth to which one can see into the water column typically ***decreases, and vice-versa.***

  The historical data (the bottom graph) show that the 2005 mean transparency is ***greater than*** the state median and was ***slightly greater than*** the similar lake median (refer to Appendix F for more information about the similar lake median).

  Overall, the statistical analysis of the historical data (the bottom graph) shows that the mean annual transparency has ***not significantly changed*** since monitoring began. Specifically, the transparency has ***fluctuated between 3.70 and 6.95 meters*** and has ***not continually increased or decreased*** since **1989**. (Note: Please refer to Appendix E for the detailed statistical analysis explanation and data print out.)

  Typically, high intensity rainfall causes sediment erosion to flow into lakes and streams, thus increasing turbidity and decreasing clarity. Efforts should continually be made to stabilize stream banks, lake shorelines, disturbed soils within the watershed, and especially dirt roads located immediately adjacent to the edge of tributaries and the lake. Guides to Best Management Practices designed to reduce, and possibly even eliminate, nonpoint source pollutants, such as sediment loading, are available from DES upon request.

- **Figure 3 and Table 8:** The graphs in Figure 3 (Appendix A) show the amount of epilimnetic (upper layer) phosphorus and hypolimnetic (lower layer) phosphorus; the inset graphs show current year data. Table 8 (Appendix B) lists the annual maximum, minimum, and median concentration for each deep spot layer and each tributary since the lake has joined VLAP.

  Phosphorus is the limiting nutrient for plant and algae growth in New Hampshire's freshwater lakes and ponds. Excessive phosphorus in a lake can lead to increased plant and algal growth over time. **The median summer total phosphorus concentration in the epilimnion (upper layer) of New Hampshire's lakes and ponds is 12 ug/L. The median summer phosphorus concentration in the hypolimnion (lower layer) is 14 ug/L.**

  The current year data for the epilimnion (the top inset graph) show that the phosphorus concentration ***decreased steadily*** from **June** to **August**.

  The historical data show that the 2005 mean epilimnetic phosphorus concentration is ***slightly less than*** the state median and is ***greater than*** the similar lake median (refer to Appendix F for more information about the similar lake median).

  The current year data for the hypolimnion (the bottom inset graph) show that the phosphorus concentration ***increased steadily*** from **June** to **August** which indicates that **internal phosphorus loading** is occurring in the hypolimnion.

  The turbidity of the hypolimnion (lower layer) sample continued to be ***elevated*** on **each** sampling event. This suggests that the lake bottom is covered by a thick organic layer of sediment which is easily disturbed. When the lake bottom is disturbed, sediment, which typically contains attached phosphorus, is released into the water column. When collecting the hypolimnion sample, make sure that there is no sediment in the Kemmerer Bottle before filling the sample bottles.

  The historical data show that the 2005 mean hypolimnetic phosphorus concentration is ***much greater than*** the state median and the similar lake median (refer to Appendix F for more information about the similar lake median).

  Overall, the statistical analysis of the historical data shows that the phosphorus concentration in the epilimnion (upper layer) and the hypolimnion (lower layer) has ***not significantly changed*** since monitoring began. Specifically, the epilimnetic phosphorus concentration has ***fluctuated between 6.5 and 21.0 ug/L*** and the hypolimnetic phosphorus concentration has ***fluctuated between approximately 45 and 269 ug/L*** since **1989.** (Note: Please refer to Appendix E for the detailed statistical analysis explanation and data print out.)

One of the most important approaches to reducing phosphorus loading to a waterbody is to continually educate watershed residents about its sources and how excessive amounts can adversely impact the ecology and the recreational, economical, and ecological value of lakes and ponds. Phosphorus sources within a lake or pond's watershed typically include septic systems, animal waste, lawn fertilizer, road and construction erosion, and natural wetlands.

## TABLE INTERPRETATION

- **Table 2: Phytoplankton**

Table 2 (Appendix B) lists the current and historical phytoplankton species observed in the lake. Specifically, this table lists the three most dominant phytoplankton species observed in the sample and their relative abundance in the sample.

The dominant phytoplankton species observed in the **July** sample were ***Dinobryon*** **(golden-brown),** ***Ceratium*** **(dinoflagellate),** and ***Anabaena*** **(cyanobacteria).**

Phytoplankton populations undergo a natural succession during the growing season (Please refer to the "Biological Monitoring Parameters" section of this report for a more detailed explanation regarding seasonal plankton succession). Diatoms and golden-brown algae are typical in New Hampshire's less productive lakes and ponds.

- **Table 2: Cyanobacteria**

A **small amount** of the cyanobacterium ***Anabaena*** was observed in the **July** plankton sample. ***This species, if present in large amounts, can be toxic to livestock, wildlife, pets, and humans.*** (Please refer to the "Biological Monitoring Parameters" section of this report for a more detailed explanation regarding cyanobacteria).

Cyanobacteria can reach nuisance levels when phosphorus loading from the watershed to surface waters is increased (this is often caused by rain events) and favorable environmental conditions occur (such as a period of sunny, warm weather).

The presence of cyanobacteria serves as a reminder of the lake's delicate balance. Watershed residents should continue to act proactively to reduce nutrient loading to the lake by eliminating fertilizer use on lawns, keeping the lake shoreline natural, re-vegetating cleared areas within the watershed, and properly maintaining septic systems and roads.

In addition, residents should also observe the lake in September and October during the time of fall turnover (lake mixing) to document any algal blooms that may occur. Cyanobacteria have the ability to regulate their depth in the water column by producing or releasing gas from vesicles. However, occasionally lake mixing can affect their buoyancy and cause them to rise to the surface and bloom. Wind and currents tend to "pile" cyanobacteria into scums that accumulate in one section of the lake. If a fall bloom occurs, please collect a sample (any clean jar or bottle will be suitable) and contact the VLAP Coordinator.

- **Table 4: pH**

Table 4 (Appendix B) presents the in-lake and tributary current year and historical pH data.

pH is measured on a logarithmic scale of 0 (acidic) to 14 (basic). pH is important to the survival and reproduction of fish and other aquatic life. A pH below 6.0 limits the growth and reproduction of fish. A pH between 6.0 and 7.0 is ideal for fish. The median pH value for the epilimnion (upper layer) in New Hampshire's lakes and ponds is **6.6**, which indicates that the surface waters in the state are slightly acidic. For a more detailed explanation regarding pH, please refer to the "Chemical Monitoring Parameters" section of this report.

The mean pH at the deep spot this season ranged from **6.70** in the hypolimnion to **7.41** in the epilimnion, which means that the water is ***slightly acidic near the lake bottom and slightly basic near the lake surface.***

It is important to point out that the pH in the hypolimnion (lower layer) was ***lower (more acidic)*** than in the epilimnion (upper layer). This increase in acidity near the lake bottom is likely due the decomposition of organic matter and the release of acidic by-products into the water column.

- **Table 5: Acid Neutralizing Capacity**
  Table 5 (Appendix B) presents the current year and historical epilimnetic ANC for each year the lake has been monitored through VLAP.

  Buffering capacity (ANC) describes the ability of a solution to resist changes in pH by neutralizing the acidic input. The median ANC value for New Hampshire's lakes and ponds is **4.9 mg/L**, which indicates that many lakes and ponds in the state are at least "moderately vulnerable" to acidic inputs. For a more detailed explanation, please refer to the "Chemical Monitoring Parameters" section of this report.

  The mean Acid Neutralizing Capacity (ANC) of the epilimnion (the upper layer) was **23.7 mg/L** this season, which is ***much greater than*** the state median. In addition, this indicates that the lake ***has a low vulnerability*** to acidic inputs (such as acid precipitation).

- **Table 6: Conductivity**
  Table 6 (Appendix B) presents the current and historical conductivity values for tributaries and in-lake data. Conductivity is the numerical expression of the ability of water to carry an electric current (which is determined by the number of negatively charged ions from metals, salts, and minerals in the water column). The median conductivity value for New Hampshire's lakes and ponds is **40.0 uMhos/cm**. For a more detailed explanation, please refer to the "Chemical Monitoring Parameters" section of this report.

  The mean annual conductivity in the epilimnion at the deep spot this season was **81.27 uMhos/cm**, which is ***greater than*** the state median.

  Overall, the conductivity has ***increased*** in the lake, inlet tributaries, and the outlet since monitoring began. Typically, sources of increased conductivity are due to human activity. These activities include failed or marginally functioning septic systems, agricultural runoff, and road runoff (which contains road salt during the spring snow melt). New development in the watershed can alter runoff patterns and expose new soil and bedrock areas, which could contribute to increasing conductivity. In addition, natural sources, such as iron and manganese deposits in bedrock, can influence conductivity.

  We recommend that your monitoring group conduct a shoreline conductivity survey of the lake and the tributaries with ***elevated*** conductivity to help pinpoint the sources of conductivity.

*To learn how to conduct a shoreline or tributary conductivity survey, please refer to the 2004 "Special Topic Article" or contact the VLAP Coordinator.*

It is possible that de-icing materials applied to nearby roadways during the winter months may be influencing the conductivity in the lake. In New Hampshire, the most commonly used de-icing material is salt (sodium chloride).

Therefore, we recommend that the **epilimnion** (upper layer) and the inlets near roadways and driveways be sampled for chloride next season. This sampling may help us pinpoint what areas of the watershed which are contributing to the increasing in-lake conductivity.

*Please note that there will be an additional cost for each of the chloride samples and that these samples must be analyzed at the DES laboratory in Concord. In addition, it is best to conduct chloride sampling in the spring as the snow is melting and during rain events.*

- **Table 8: Total Phosphorus**
  Table 8 (Appendix B) presents the current year and historical total phosphorus data for in-lake and tributary stations. Phosphorus is the nutrient that limits the algae's ability to grow and reproduce. Please refer to the "Chemical Monitoring Parameters" section of this report for a more detailed explanation.

  The phosphorus concentration was ***slightly elevated*** in **Inlet 1** (**21 ug/L**) on **July** sampling event and the turbidity (**1.35 NTUs**) was also ***slightly elevated.***

  The phosphorus concentration was ***slightly elevated*** in **Inlet 6** (**21 ug/L**) on the **July** sampling, however, the turbidity (**0.75 NTUs**) was ***not*** particularly elevated.

  It had rained approximately 2 inches during the 24 hours prior to the **July** sampling event which suggests that the rain event caused phosphorus-enriched stormwater runoff to the **Inlet 1** and **Inlet 6** tributaries and that erosion may be occurring in the **Inlet 1** subwatershed.

  If you suspect that erosion is occurring in these areas of the watershed, we recommend that your monitoring group conduct stream surveys and storm event sampling along these tributaries. This additional sampling may allow us to determine what is causing the ***elevated*** levels of turbidity and phosphorus.

*For a detailed explanation on how to conduct rain event sampling and stream surveys, please refer to the 2002 VLAP Annual Report "Special Topic Article" or contact the VLAP Coordinator.*

- **Table 9 and Table 10: Dissolved Oxygen and Temperature Data**
  Table 9 (Appendix B) shows the dissolved oxygen/temperature profile(s) for the 2005 sampling season. Table 10 (Appendix B) shows the historical and current year dissolved oxygen concentration in the hypolimnion (lower layer). The presence of dissolved oxygen is vital to fish and amphibians in the water column and also to bottom-dwelling organisms. Please refer to the "Chemical Monitoring Parameters" section of this report for a more detailed explanation.

  The dissolved oxygen concentration was greater than **100%** saturation at **4** meters at the deep spot on the **July** sampling event. Wave action from wind can also dissolve atmospheric oxygen into the upper layers of the water column. Layers of algae can also increase the dissolved oxygen in the water column, since oxygen is a by-product of photosynthesis. Considering that the depth of the photic zone (depth to which sunlight can penetrate into the water column) was approximately **4.45** meters on this date (as shown by the Secchi-disk transparency), and that the metalimnion (the layer of rapid decrease in water temperature and increase in water density – a place where algae are often found) was located between approximately **4** and **7** meters, we suspect that an abundance of algae in the metalimnion caused the oxygen super saturation.

  The dissolved oxygen concentration was ***lower in the metalimnion and hypolimnion (lower layer) than in the epilimnion (upper layer)*** at the deep spot of the lake on the **July** sampling event. As stratified lakes age, and as the summer progresses, oxygen typically becomes ***depleted*** in the hypolimnion by the process of decomposition. Specifically, the loss of oxygen in the hypolimnion results primarily from the process of biological breakdown of organic matter (i.e.; biological organisms use oxygen to break down organic matter), both in the water column and particularly at the bottom of the lake where the water meets the sediment. When oxygen levels are depleted to less than 1 mg/L in the hypolimnion (as it has been on most annual biologist visits), the phosphorus that is normally bound up in the sediment may be re-released into the water column (a process referred to as ***internal phosphorus loading***).

- **Table 11: Turbidity**

  Table 11 (Appendix B) lists the current year and historical data for in-lake and tributary turbidity. Turbidity in the water is caused by suspended matter, such as clay, silt, and algae. Water clarity is strongly influenced by turbidity. Please refer to the "Other Monitoring Parameters" section of this report for a more detailed explanation.

  As discussed previously, the turbidity of the hypolimnion (lower layer) continued to be ***elevated*** on **each** sampling event this season. This suggests that the lake bottom is covered by a thick organic layer of sediment which is easily disturbed.

  The turbidity was ***slightly elevated*** in many of the inlet tributary samples and the outlet samples on at least one sampling event this season which suggests that the stream bottom may have been disturbed while sampling or that erosion is occurring in certain subwastersheds.

  When the stream bottom is disturbed, sediment, which typically contains attached phosphorus, is released into the water column. When collecting samples in the inlets, please be sure to sample where the stream is flowing and where the stream is deep enough to collect a "clean" sample.

  If you suspect that erosion is occurring in a particular subwatershed, we recommend that your monitoring group conduct stream surveys and storm event sampling along the tributary. This additional sampling may allow us to determine what is causing the ***elevated*** levels of turbidity.

  *For a detailed explanation on how to conduct rain event sampling and stream surveys, please refer to the 2002 VLAP Annual Report "Special Topic Article" or contact the VLAP Coordinator.*

- **Table 12: Bacteria (*E.coli*)**

  Table 12 lists only the historical data for bacteria *(E.coli)* testing. (Please note that Table 12 now lists the maximum and minimum results for all past sampling seasons.) *E. coli* is a normal bacterium found in the large intestine of humans and other warm-blooded animals. *E.coli* is used as an indicator organism because it is easily cultured and its presence in the water, in defined amounts, indicates that sewage **MAY** be present. If sewage is present in the water, potentially harmful disease-causing organisms **MAY** also be present.

It should be noted that bacteria sampling was not conducted this year. If residents are concerned about sources of bacteria such as failing septic systems, animal waste, or waterfowl waste, it is best to conduct *E. coli* testing when the water table is high, when beach use is heavy, or immediately after rain events.

- **Table 14: Current Year Biological and Chemical Raw Data**
  This table lists the most current sampling season results. Since the maximum, minimum, and annual mean values for each parameter are not shown on this table, this table displays the current year "raw" (meaning unprocessed) data. The results are sorted by station, depth zone (epilimnion, metalimnion, and hypolimnion) and parameter.

- **Table 15: Station Table**
  As of the Spring of 2004, all historical and current year VLAP data are included in the DES Environmental Monitoring Database (EMD). To facilitate the transfer of VLAP data into the EMD, a new station identification system had to be developed. While volunteer monitoring groups can still use the sampling station names that they have used in the past (and are most familiar with), an EMD station name also exists for each VLAP sampling location. For each station sampled at your lake, Table 15 identifies what EMD station name corresponds to the station names you have used in the past and will continue to use in the future.

## DATA QUALITY ASSURANCE AND CONTROL

**Annual Assessment Audit:**

During the annual visit to your lake, the biologist conducted a "Sampling Procedures Assessment Audit" for your monitoring group. Specifically, the biologist observed the performance of your monitoring group while sampling and filled out an assessment audit sheet to document the ability of the volunteer monitors to follow the proper field sampling procedures (as outlined in the VLAP Monitor's Field Manual). This assessment is used to identify any aspects of sample collection in which volunteer monitors fail to follow proper procedures, and also provides an opportunity for the biologist to retrain the volunteer monitors as necessary. This will ultimately ensure that the samples that the volunteer monitors collect are truly representative of actual lake and tributary conditions.

Overall, your monitoring group did an ***excellent*** job collecting samples on the annual biologist visit this season! Specifically, the members of your monitoring group followed the proper field sampling procedures and there was no need for the biologist to provide additional training. Keep up the good work!

**Sample Receipt Checklist:**

Each time your monitoring group dropped off samples at the laboratory this summer, the laboratory staff completed a sample receipt checklist to assess and document if the volunteer monitors followed proper sampling techniques when collecting the samples. The purpose of the sample receipt checklist is to minimize, and hopefully eliminate, future re-occurrences of improper sampling techniques.

Overall, the sample receipt checklist showed that your monitoring group did an ***excellent*** job when collecting samples and submitting them to the laboratory this season! Specifically, the members of your monitoring group followed the proper field sampling procedures and there was no need for the laboratory staff to contact your group with questions, and no samples were rejected for analysis.

## USEFUL RESOURCES

*Best Management Practices to Control Nonpoint Source Pollution: A Guide for Citizens and Town Officials*, NHDES Booklet WD-03-42, (603) 271-2975.

*Cyanobacteria in New Hampshire Waters Potential Dangers of Blue-Green Algae Blooms*, NHDES Fact Sheet WMB-10, (603) 271-2975 or www.des.state.nh.us/factsheets/wmb/wmb-10.htm.

*Erosion Control for Construction in the Protected Shoreland Buffer Zone*, NHDES Fact Sheet WD-SP-1, (603) 271-2975 or www.des.state.nh.us/factsheets/sp/sp-1.htm.

*Impacts of Development Upon Stormwater Runoff,* NHDES Fact Sheet WD-WQE-7, (603) 271-2975 or www.des.state.nh.us/factsheets/wqe/wqe-7.htm.

*Lake Protection Tips: Some Do's and Don'ts for Maintaining Healthy Lakes*, NHDES Fact Sheet WD-BB-9, (603) 271-2975 or www.des.state.nh.us/factsheets/bb/bb-9.htm.

*Low Impact Development Hydrologic Analysis.* Manual prepared by Prince George's County, Maryland, Department of Environmental

Resources. July 1999. To access this document, visit www.epa.gov/owow/nps/lid_hydr.pdf or call the EPA Water Resource Center at (202) 566-1736.

*Low Impact Development: Taking Steps to Protect New Hampshire's Surface Waters* NHDES Fact Sheet WD-WMB-16, (603) 271-2975 or www.des.state.nh.us/factsheets/wmb/wmb-17.htm.

*Proper Lawn Care In the Protected Shoreland, The Comprehensive Shoreland Protection Act,* NHDES Fact Sheet WD-SP-2, (603) 271-2975 or www.des.state.nh.us/factsheets/sp/sp-2.htm.

*Road Salt and Water Quality,* NHDES Fact Sheet WD-WMB-4, (603) 271-2975 or www.des.state.nh.us/factsheets/wmb/wmb-4.htm.

*Soil Erosion and Sediment Control on Construction Sites,* NHDES Fact Sheet WQE-6, (603) 271-2975 or www.des.state.nh.us/factsheets/wqe/wqe-6.htm.

*Watershed Districts and Ordinances,* NHDES Fact Sheet WD-WMB-16, (603) 271-2975 or www.des.state.nh.us/factsheets/wmb/wmb-16.htm.